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ARI Research Note 89-06

Detailed Design Specification for Product 6: Personnel Characteristics Requirements Aid

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for

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The U.S. Army Research Institute (ARI) is developing a set of software-based aids for the evaluation of weapons system designs in terms of manpower and personnel requirements. This report is a detailed design specification for software that will determine the operator and maintainer characteristics required to achieve a given weapons system's criterion performance. This specification includes a statistical analysis of ARI's Project A data base, equations that link scores on the Armed Services Vocational Aptitude Battery (ASVAB) to performance on tasks, and the interface design of the aid itself. Although the development of this design has not been funded, the design specification may prove useful for other projects. Keywords:

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FOREWORD

The Army Research Institute (ARI) is developing a suite of six interconnected, software-based methods to aid in the successful integration of soldiers and their equipment. Software-based methods are only as effective as their design specifications. As part of this effort, ARI defined the requirements for writing a series of detailed design specifications. These specifications will provide interface designs, equations, and data sources and will serve as blueprints for software and data base development.

Because this project is important, ARI developed alternative design specifications for several of the methods. When these alternative designs were developed, ARI selected those with the most promise and the lowest risk. However, the designs that were not selected showed considerable merit. It is our belief that the designs not selected may offer significant information and be useful in other programs. The following report is about one of the design specifications that was not selected. It describes in detail how to build software to aid in evaluating a system design by determining the levels of physical, perceptual, and cognitive characteristics required of operators and maintainers to reach system design criterion performance.

DETAILED DESIGN SPECIFICATION FOR PRODUCT 6: PERSONNEL CHARACTERISTICS REQUIREMENTS AID

EXECUTIVE SUMMARY

The U.S. Army Research Institute (ARI) is sponsoring the development of six computerized MANPRINT decision aids. Four of the aids will be used to establish weapon system performance requirements and the Army's manpower, personnel, and training constraints before weapons systems are designed. The other two decision aids will be used to evaluate the manpower and personnel characteristics required by a given system design.

The ARI program is being conducted in three phases: concept development, design specification, and product development. This report results from phase 2 of the program and presents the design specifications for a product ("Product 6") that will aid in evaluating a weapon system design by helping the user to identify the kinds and levels of personnel characteristics required to operate and maintain a given design to specific performance criteria. The characteristics and their levels are provided for each operational and maintenance job.

The basic procedure for this product is to have the user respond to a set of questions concerning the activities that humans will need to perform in order to operate or maintain the system under evaluation. Thus, it was necessary first to establish a set of human activities, with associated measures of human performance, that would encompass the actions that could be expected during the operation and maintenance of an Army system. A determination was made of the human ability measures to include in the evaluation process. Finally, the ability characteristics were empirically linked to the performance measures through statistical analyses that draw on ARI's Project A data base. This specification includes the algorithms developed from the statistical analysis, the software architecture, and the interface design.

DETAILED DESIGN SPECIFICATION FOR PRODUCT 6: PERSONNEL CHARACTERISTICS REQUIREMENTS AID

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DETAILED DESIGN SPECIFICATION FOR PRODUCT 6:
PERSONNEL CHARACTERISTICS REQUIREMENTS AID

Section 1.0

Product Six Introduction

1.1 Purpose

The goal of Product Six is to allow its users to identify the level of personnel characteristics most appropriate for a proposed system. These characteristics must be identified in terms of matching the task demands of the jobs, meeting an appropriate level of performance criteria, and maximizing total system performance effectiveness. The key process here is in providing a linkage between system characteristics expressed as human operator and maintainer tasks (clustered into jobs if Product Five is available), and soldier characteristics (attributes or abilities that can influence task performance).

Product Six is to provide a design evaluation aid that will predict the significant soldier characteristics and levels of those characteristics that are required to operate and to maintain to a specified level of performance the hardware and software from a given system design. The product itself is not meant to determine whether or not the system design is "acceptable," but it must provide relevant information that can be used in conjunction with the output of Product Five to determine if the proposed design matches the Army's expected human resource supply and limitations.

1.2 Product Overview

Product Six will output the levels of the human ability characteristics required to perform the operation and maintenance activities of Army systems. In order to reach this goal, it will step the user through a series of simple yes-no questions that will define the activities that will be performed during the system task or job that is being evaluated. Once these activities have been defined, a set of empirically derived evaluation algorithms will determine the levels of the appropriate human abilities required to perform those activities in a manner which secures system performance goals.

The output from the evaluation process can be displayed to the user via the computer screen or saved in a system data base for further analysis. Evaluation output can be displayed either as the abilities required to perform a particular task or be integrated to show the requirements for successful performance at the job level.

1.3 Product Users

The primary users of Product Six will be Army military and civilian personnel conducting MANPRINT appraisals of new systems. While such users could be found throughout TRADOC, AMC, and the DA Staff, the primary users are likely to be located at the combat development centers. The combat development centers now have responsibility for preparing the target audience descriptions (TADS) that define the soldier supply constraints for new systems. They are also responsible for the determination of whether a proposed system satisfies those constraints. Table 1.3.1 lists the TRADOC combat development centers, including the appropriate attention line for MANPRINT evaluations.

1.4 Specification Overview

There are two major sections to this specification. Section 2.0 describes the fundamental approach and research of the product. This section summarizes how the product was developed and how it will be used. This information is designed to serve as a framework for the more detailed screen and control specifications presented in Section 3.0, which contains the actual design requirements to be executed by the software programmers.

Table 1.3.1

Potential Army Users of Product Six

Aviation Center Ft. Rucker, AL 36362 ATTN: ATZQ-CDM	Air Defense Artillery School Ft. Bliss, TX 79916 ATTN: ATSA-CMD
Armor School Ft. Knox, KY 40121 ATTN: ATSB-CD	Aviation Logistics School Ft. Eustis, VA 23604 ATTN: ATSQ-TDN
Chaplain School Ft. Monmouth, NJ 07703 ATTN: ATSC-DCD	Chemical School Ft. McClellan, AL 36205 ATTN: ATZN-CM
Engineer School Ft. Belvoir, VA 22060 ATTN: ATZA-CDM	Field Artillery School Ft. Sill, OK 73503 ATTN: ATSF-CML
Infantry School Ft. Benning, GA ATTN: ATSH-CD	Intelligence Center Ft. Huachuca, AZ 31905 ATTN: ATSI-CD
Intelligence School Ft. Devens, MA 01433 ATTN: ATSI-CDO	JFK Special Warfare Center Ft. Bragg, NC. 28307 ATTN: ATSU-CD
Military Police School Ft. McClellan, AL 36205 ATTN: ATZN-MP-CCC	Ordnance Center Aberdeen PG, MD 21005 ATTN: ATSL-CD
Ordnance Missile and Munitions School Redstone Arsenal, AL 35897 ATTN: ATSL-CD	Quartermaster School Ft. Lee, VA 23801 ATTN: ATSK-CME

Table 1.3.1
Potential Army Users of Product Six
(continued)

Signal School
Ft. Gordon, VA 23801
ATTN: ATSM-CDM

Academy of Health Sciences
Ft. Sam Houston, TX 78234
ATTN: HSA-CDM

U.S. Army Medical Material
Development Activity
Ft. Detrick, MD 21701
ATTN: SGRD-UMS

Transportation School
Ft. Eustis, VA 23604
ATTN: ATSP-CDM

U.S. Army Environmental
Hygiene Agency
Aberdeen PG, MD 21010
ATTN: HSHB-MO-A

U.S. Army Aeromedical
Research Lab
Ft. Rucker, AL 36362

Section 2.0
Product Six System Approach

2.1 Overview

As a s⁻stem specification, the primary purpose of this document is to describe the Product Six process so that it can be implemented by software programmers. Section three of this manuscript accomplishes this goal. However, we believe that the understanding of (and confidence in) how the product will function can be enhanced by knowledge as to how it was developed. Towards this goal this section presents a very brief synopsis of the development of the evaluation procedures contained in section Three.

There were three major aspects to the evolution of these procedures. The first aspect of this process was the establishment of a set of human activities, with associated measures of human performance, that would encompass the actions that could be expected during the operation and maintenance of an Army system. Concurrent with this activity, the realmsof potential human ability measures or characteristics were reviewed to determine which measures should be included in the evaluation process. Finally the ability characteristics were empirically linked to the performance measures through statistical analyses.

2.2 Development of Activity Measures

The basic procedure for this product is to have the user respond to a set of questions concerning the activities that humans will need to perform in order to operate or maintain the system under evaluation. The procedure, therefore, called for the establishment of a taxonomy of human activities could encompass the range of actions that might be required of Army soldiers. The initial Product Six taxonomy was formed by merging and modifying two existing systems within the literature. These systems were McCormick's (1985) job dimensions and the behavior taxonomy developed by Berliner, Angell, and

Shearer (1964). The resulting classification system is shown in Figure 2.2.1

In order to obtain performance measures for the categories in this system, we turned to the Project A Longitudinal Research Data Base or LRDB. As part of its concurrent validation effort Project A administered over 2,000 hands-on performance measures (Campbell, Campbell, Rumsey, & Edwards; 1985) to hundreds of soldiers in the U.S. and Europe. These performance measures corresponded to the steps involved in performing Army tasks and were scored on a go versus no-go criterion. All of these steps were sorted into the elementary categories of the activity taxonomy shown in Figure 2.2.1. A given step could be placed in more than one taxonomic category. In this manner a set of performance measures could be derived and calculated for each activity.

After the initial sorting of performance measures into the basic activity categories, some of the categories had insufficient data for reliable statistical analysis. For this reason some activities were combined to form a new activity taxonomy with sufficient data in each cell for reliable analysis. This final taxonomy is given in Table 2.2.1 and the distribution of performance measures within it is presented in Figure 2.2.2. As can be seen in the figure this final combination of activity categories led to the sorting of sizeable numbers of performance measures within each category. This distribution of performance measures was assessed as satisfactory to provide good criterion reliability for the regression analyses to follow.

This system formed the basis for the control processes of the product. The middle two columns of Table 2.2.1 document the role of the taxonomy in the product's evaluation algorithms. The flow diagram index number and evaluation algorithm number mark the location and role of that activity in the evaluation control diagrams (see Figure 3.2.2). The r column indicates the degree that activity was predicted by the ability measures after the final statistical analysis.

Figure 2.2.1

Initial Activities Taxonomy

Basic Categories of Human Activities (Generic Tasks)

Search for and Receiving Information

1. Detects	Evaluation of Sensory/Visual Input
2. Inspects	Evaluation of Sensory/Visual Input; Check
3. Scans	Viewing Visual Input from Devices/Materials; e.g., read 6 digits
4. Surveys	Viewing Visual Input from Devices/Materials e.g., observe into chamber

Identifying Objects, Actions, Events

5. Discriminates perceptual (visual/auditory input) interpretation
6. Identifies, verifies
7. Locates
8. Input from Representational Sources
   e.g., filling up forms, reading TM while performing engine maintenance
9. Environmental Awareness
   e.g., check for leakage/the presence of

T. Complete on Time Criterion
   e.g., read coordinate within 1 minute

Information Processing

10. Calculates	Numerical Computation; Measure
11. Itemizes	Information Ordering; Entering Items e.g., (announce elements) in order, record
12. Translates	e.g., converts distance to paces
13. Interpolates/extrapolate	
13a. Memorization	working memory, e.g., doing x before y

Problem Solving and Decision Making

14. Analyze
15. Compares
16. Estimates
17. Plans
18. Judgment e.g., determine distance
19. Deductive Reasoning
20. Inductive Reasoning
21. Use of Job-related Knowledge (from memory)
    e.g., use correct procedures to (authenticate, send message)

A. Accuracy Criterion
    e.g., should be, so that, must not

S. Follow Task Sequence

M. Use of Technical Manuals

Communication Processes

22. Advises Communicating Instructions/Directions; reply

23. Directs Communicating Instructions/Directions
24. Requests or Questioning
25. Transmits Sending/Receiving Messages, Signal/Code communications, announce
    e.g., announce elements (in order)
26. General Personal Contact
27. Interchange of Ideas/Judgments Related Information

Simple/Discrete Motor Processes

28. Activates Manipulating/Handling Activities
    e.g., turn PWR switch on, release slide to

chamber a round, depress magazine catch, or trigger

29. Connects — Manipulating/Handling Activities; disconnects; Separates; tie; install assembly e.g., join upper and lower receivers, connect CVC to intercom control box

30. Moves — General body/handling activities e.g., close cover, remove, pull, lift, place

31. Sets — Manual Control Activities e.g., set BAND switch to 53-75, push safety lock to safe position, pull the hood over head and down to shoulders, insert, secure, lock, positioning

Complex/Continuous Motor Processes

32. Adjusts — Adjusting/Operating Machines/Equipment e.g., adjust VOLUME control on intercom control box, positioning with adjustment, centering with adjustment

33. Aligns — Control Precision, Control Equipment Operation

34. Synchronizes — Manual Control/Coordination Activities manual manipulation with both hands, e.g., (charge weapon) while holding trigger to the rear

35. Tracks — Manual Control/Coordination Activities, Control Equipment Operation

36. General Body Activity versus Sedentary activities gross hand movements or body activities, Sketch; Mark, writing

37. Use of Miscellaneous Equipment/Devices e.g., use 1:50000 scale protractor

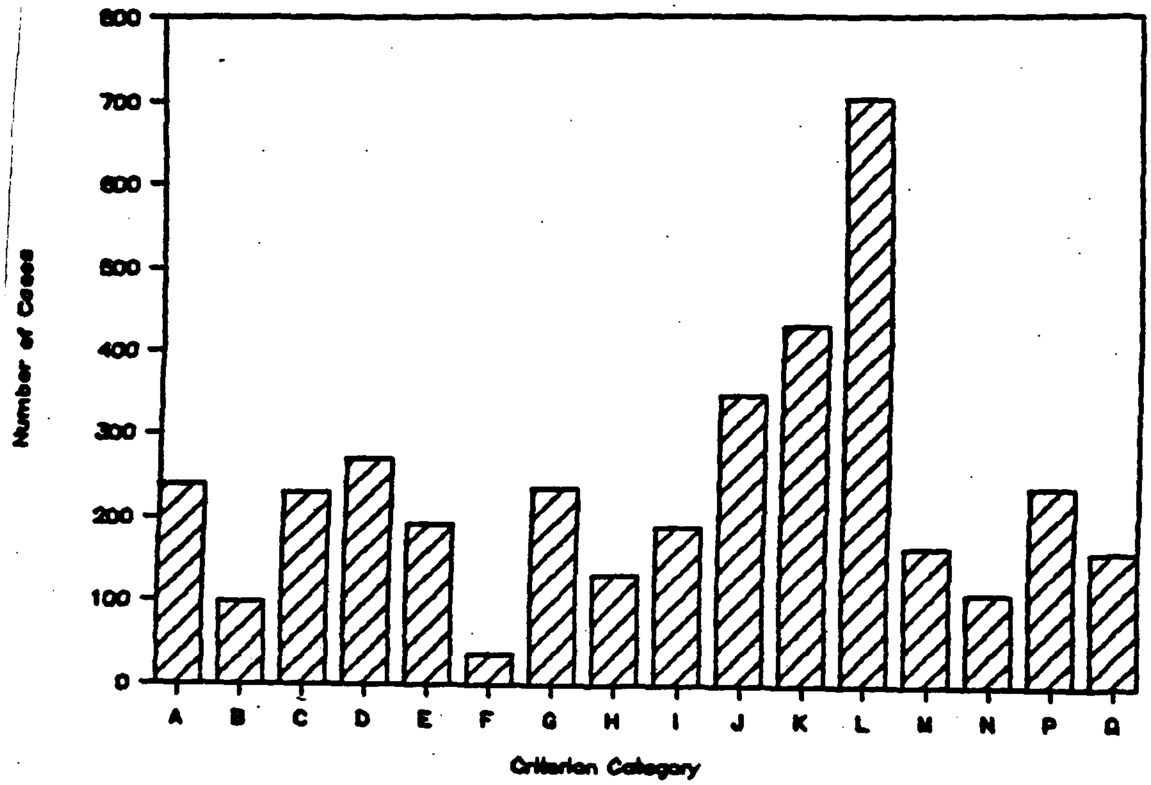
38. Skilled/Technical Activities precision, driving tractor,

* Behavior-oriented descriptors are based on or derived from (1) overall survey of tasks within the Project A documentation, (2) McCormick's (1985) job dimension titles, and the Berliner et al. taxonomy of human activities.

Table 2.2.1
Evaluation / Criterion Factors

Criterion Factor (id)	Flow Diagram Index	Evaluation Algorithm	R
Search for/receive information (A)	1100	# 1	.33
Identify objects actions and events (B)	2100	# 2	.40
Input from representational sources (C)	2200	# 3	.40
Information processing (D)	3100	# 4	.30
Problem solving / decision making (F)	4200	# 6	.30
Use of job-related knowledge (G)	4100	# 5	.37
Communications (H)	5100	# 7	.26
Connect wires and equipment (J)	6140	# 10	.24
Moves (K)	6240	# 14	.33
Sets controls (L)	6130	# 9	.30
Adjusts (M)	6220	# 12	.32
Aligns/synchronizes (N)	6120	# 8	.37
General body activity (P)	6150	# 11	.39
Use of technical equipment (Q)	6250	# 15	.32

Figure 2.2.2
Final Distribution of Performance Measures
Across Activity Categories



2.3 Selection of Human Ability Measures

The number of human ability measures that could have been included in Product Six is quite large. For example, Fleishman (1975) identifies over forty variables that are likely to effect human performance. Luckily practical considerations can be used to reduce substantially this number.

The primarily limitation to the selection of variables to include the product is the RFP's guidance that the ability variables be those that are now used or are likely to be used by the Army in an operational mode. This use may be as criteria for enlistment or as projections of potential personnel supply. In either case this guidance effectively limits the ability variables to be considered to those investigated by Project A. It was the design goal of Project A to determine the enlistment criteria for the Army of the future. The project has justly received considerable acceptance and support from the Army, but its high cost renders any similar effort in the future to be unlikely.

Project A analyses have indicated the set of ability variables that are likely to be of use to the Army. These ability measures were designated for inclusion in Product Six and are shown in Table 2.3.1. In addition to these ability measures Project A identified a number of background and interest variables that could be valuable indicators of a soldier's difficulty in adjusting to the Army environment. However, since these variables were not predictors of technical performance they were not included as part of this product's evaluation algorithms.

Table 2.3.1

Human Ability Variables Included in

Product Six Analytic Development

Ability Construct	Source of Data
Verbal	ASVAB
Numerical/Quantitative	ASVAB
Technical	ASVAB
Speed	ASVAB
Spatial	Project A
Psychomotor	Project A
Aptitude Area Composite*	ASVAB
Mental Category Score*	ASVAB

* Derived through the combination of the basic ASVAB subtests and factors.

2.4 Statistical Analysis

All of the soldiers who were administered the Project A performance measures outlined in Section 2.2 also were administered all of the ability measures contained in Table 2.3.1. The relationship between the two types of measures could, therefore, be determined through statistical analyses.

The first step in this analysis computed simple correlations between all possible combinations of performance activities and ability variables. In order to establish the stability of the results, this analysis was conducted on an MOS basis. This process led to a very large correlation matrix.

The matrix of correlations was then reviewed to select a set of variables to include in the multiple regression runs that would become the product's evaluation algorithms. The set of variables that were selected for each activity factor are given in Table 2.4.1. The values of $\underline{r}$ for the multiple regressions used to derive the evaluation algorithms were presented in the last column of Table 2.2.1. The evaluation algorithms themselves are presented in Section 3.3.

Table 2.4.1

Ability vs. Criterion Matrix

Criterion Construct	Ability: Verbal	Numerical	Technical	Speed	Spatial	Psycho-motor
Factor A					x	x
Factor B		x	x		x	
Factor C		x		x	x	
Factor D		x		x	x	
Factor F		x			x	
Factor G		x		x	x	
Factor H	x			x		
Factor I		x		x	x	
Factor J			x			
Factor K			x			x
Factor L			x		x	x
Factor M	x				x	
Factor N					x	
Factor P		x		x	x	
Factor Q		x	x	x	x	

2.5 Comparison to the JASS Procedure

The version of Product Six that came out of this process bears a surface resemblance to the JASS procedure previously developed for ARI (Rossmeissl, Tillman, Rigg, & Best; 1983). The JASS procedure also had its users step through a set of questions to achieve the determination of the abilities required to operate or maintain an Army system. This similarity is fortuitous, in that there was considerable Army and industry interest and support for the basic JASS concept as it was originally presented.

The two techniques, however, are quite different from a technical perspective. The questions contained in JASS asked its user to make direct judgments concerning the human abilities required of an MOS or task. Recent research (i.e., Smith & Rossmeissl, in press) has indicated that such judgments can very difficult for Army personnel to make. Product Six will ask its user the more simple and direct question of what will the soldier do as part of the system. The abilities that are required to perform those actions can then be determined based upon sound statistically derived algorithms.

Another important area where the two procedures differ is in the determination of the level of ability required for successful performance. In JASS, the user of the system made a subjective judgement of the level of ability that was required. For Product Six the level of the abilities that are required will be output directly through the procedure's evaluation algorithms. This output will be derived from the soldier/system performance criteria that will come from Product One.

Section 3.0

Product Six Design Specifications

3.1 Input Data Requirements

The input data requirements for Product Six are not extensive. The primary input to the process will consist human operator and maintainer tasks. One source of task information will be human factors analyses such as critical tasks analyses or the Human Engineering Design Approach Documents for operators and maintainers (HEDAD-O and HEDAD-M).

These documents describe in considerable detail (drawings, time estimates, and textual descriptions) the human tasks to be performed in operating and maintaining the proposed system. Recent major material RFPs (e.g., LHX, T800, and AFV) have required that the HEDAD-O and HEDAD-M documentation be provided very early in the design process, (i.e., before down-select or prototype development). Because of the importance now being assigned to MANPRINT concerns, it is now likely that most weapon system designs will have HEDAD information produced early in their development process. Given their high level of detail, these documents will be excellent sources of task information for Product Six.

The user should have access to system design information either through design drawings or task analyses such as the HEDAD-M or HEDAD-O. Such information is typically available at the point of time when a design is submitted to the government for evaluation.

In order to indicate the required level of performance for the human activities to be performed the user also will need system performance requirements data. This information can come from either the output of Product Three or the Mission Area Analysis (MAA).

Product Five groupings of tasks into jobs would also be of value to the user for producing summary analyses. This data would permit the evaluation of the abilities needed to perform the entire job rather than simply task requirements.

3.2 Flow Control Diagrams

The interactive structure of Product Six can be expressed in terms of process control diagrams. These flow diagrams show all of the user interactions with the product's hardware and software. Within these diagrams arrows that follow questions and run horizontally indicate a YES response from the user. Arrows that follow questions and run vertically indicate a NO response from the user. Both the YES and NO user responses will be entered from the keyboard by typing a "Y" or "N" respectively. The system software will verify that the users response was either a "Y" or "N" before storing the response and proceeding to the next module.

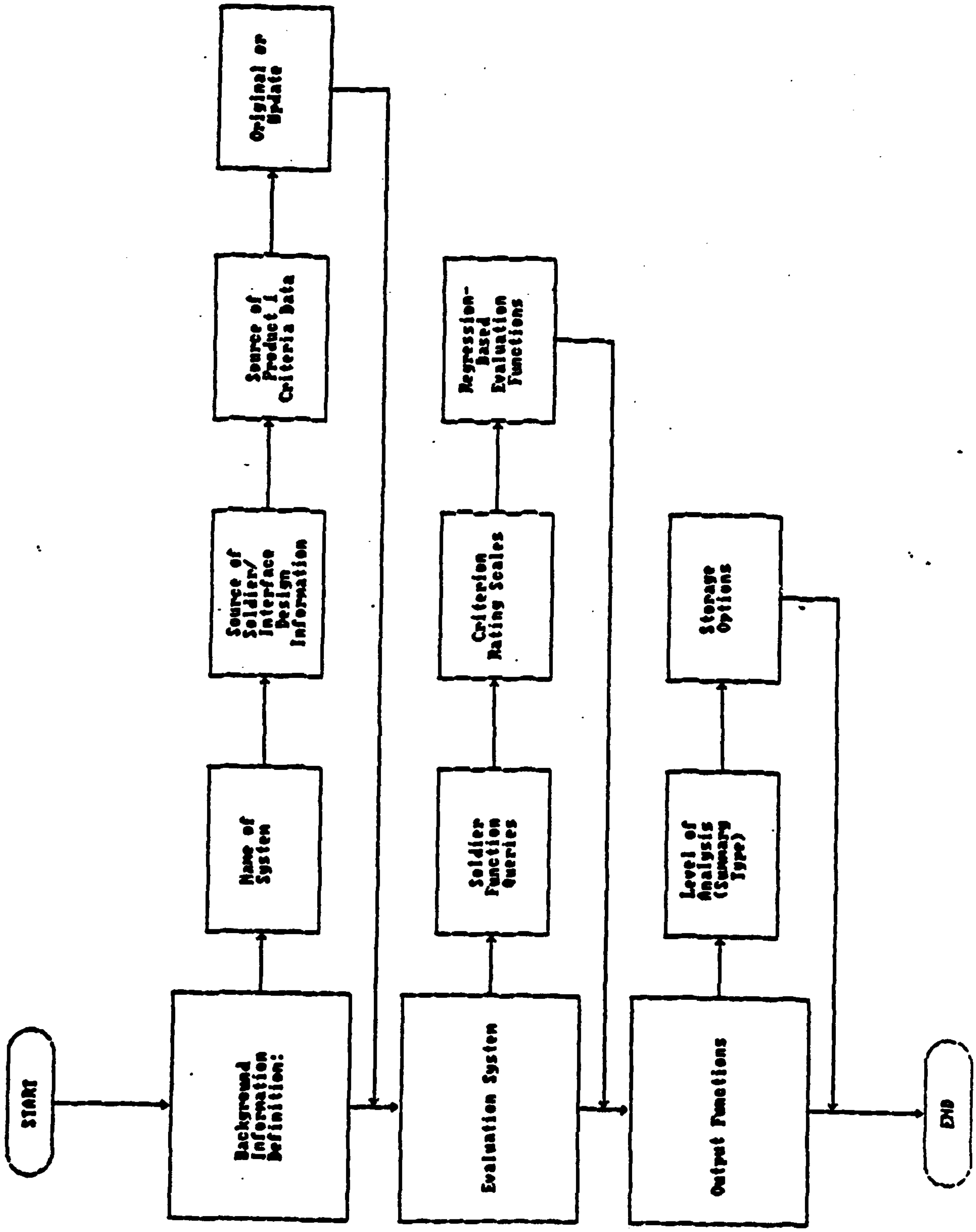
3.2.1 Overall Process Flow. Figure 3.2.1 presents the overall flow for the entire product. Each of the large boxes on the left side of this figure represents a major component or module of the process. The smaller boxes towards the right of the screen represent either user interface screens, as is the case for the boxes describing the definition of the background information, or sub-modules, as is the case for the remaining boxes.

The information displayed in the boxes representing user interface screens for the background information definition should be displayed precisely by the system hardware and software. Positions for the user to enter the appropriate background information should also be provided on the screens.

3.2.2 Evaluation System Process Flow. The major portion of Product 6 is its evaluation system. Figure 3.2.2 details the control flow for this evaluation system. Each large box in this

Figure 3.2.1

Overall Product Flow Structure



Arrows that follow questions and that run horizontally indicate YES. Arrows that follow questions and that run vertically indicate NO.

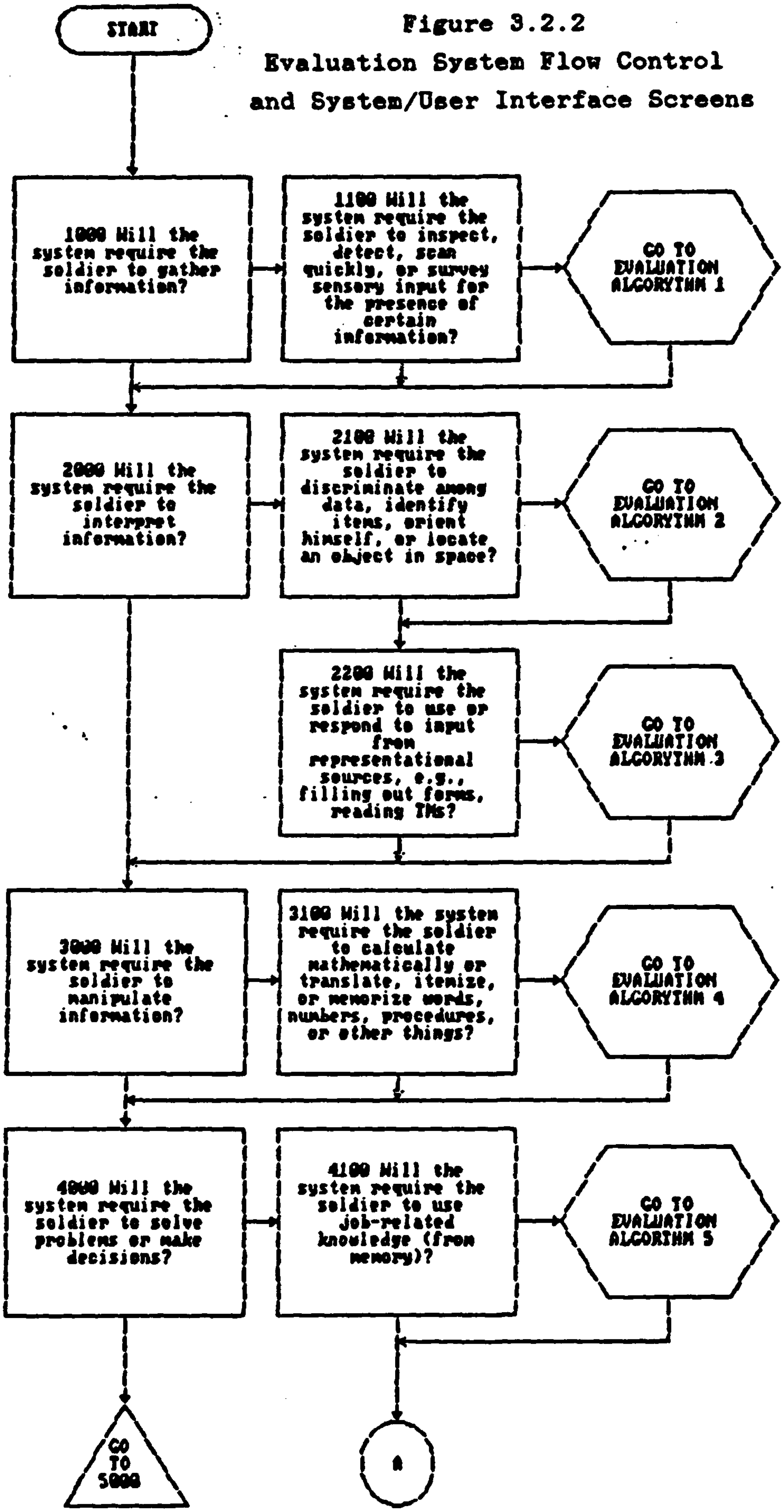
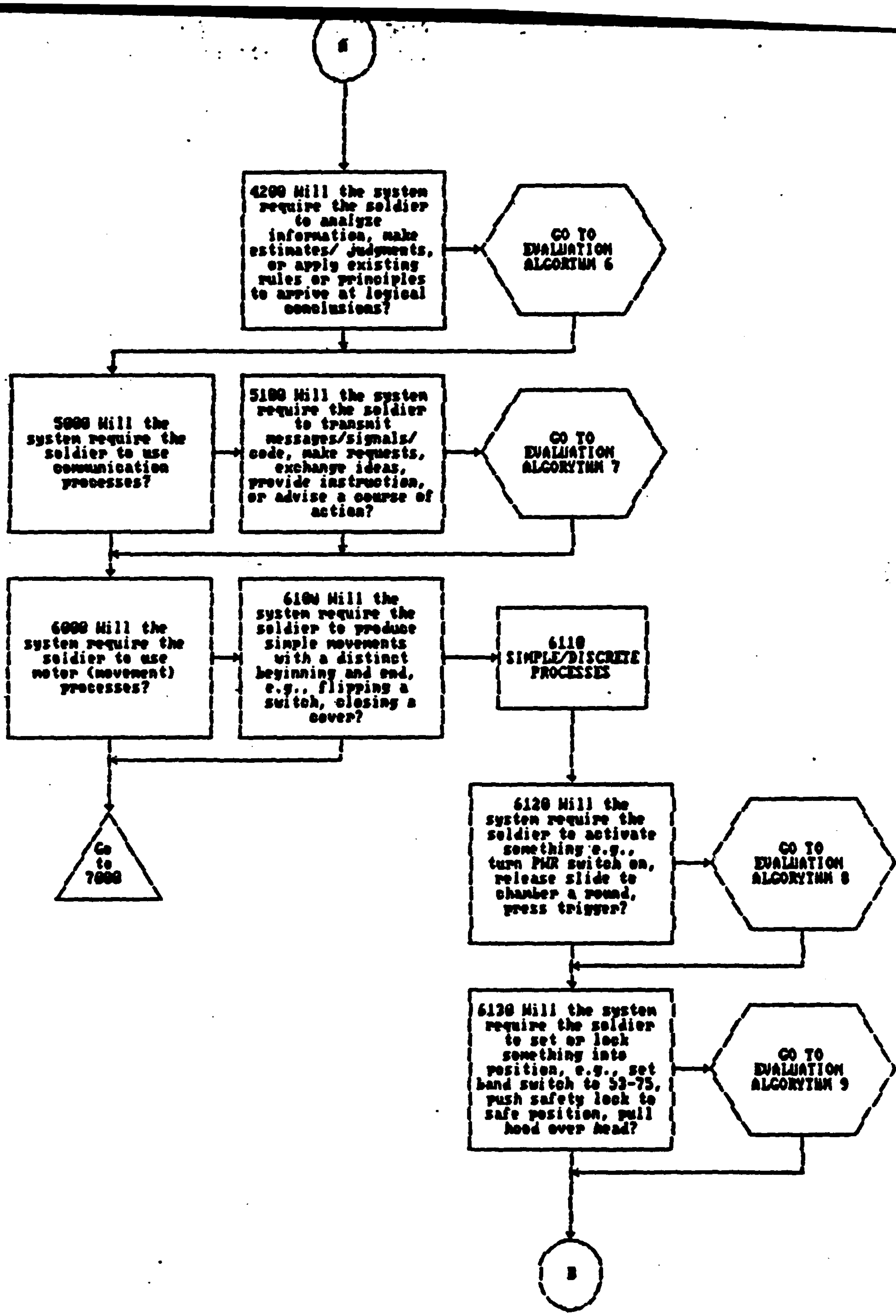
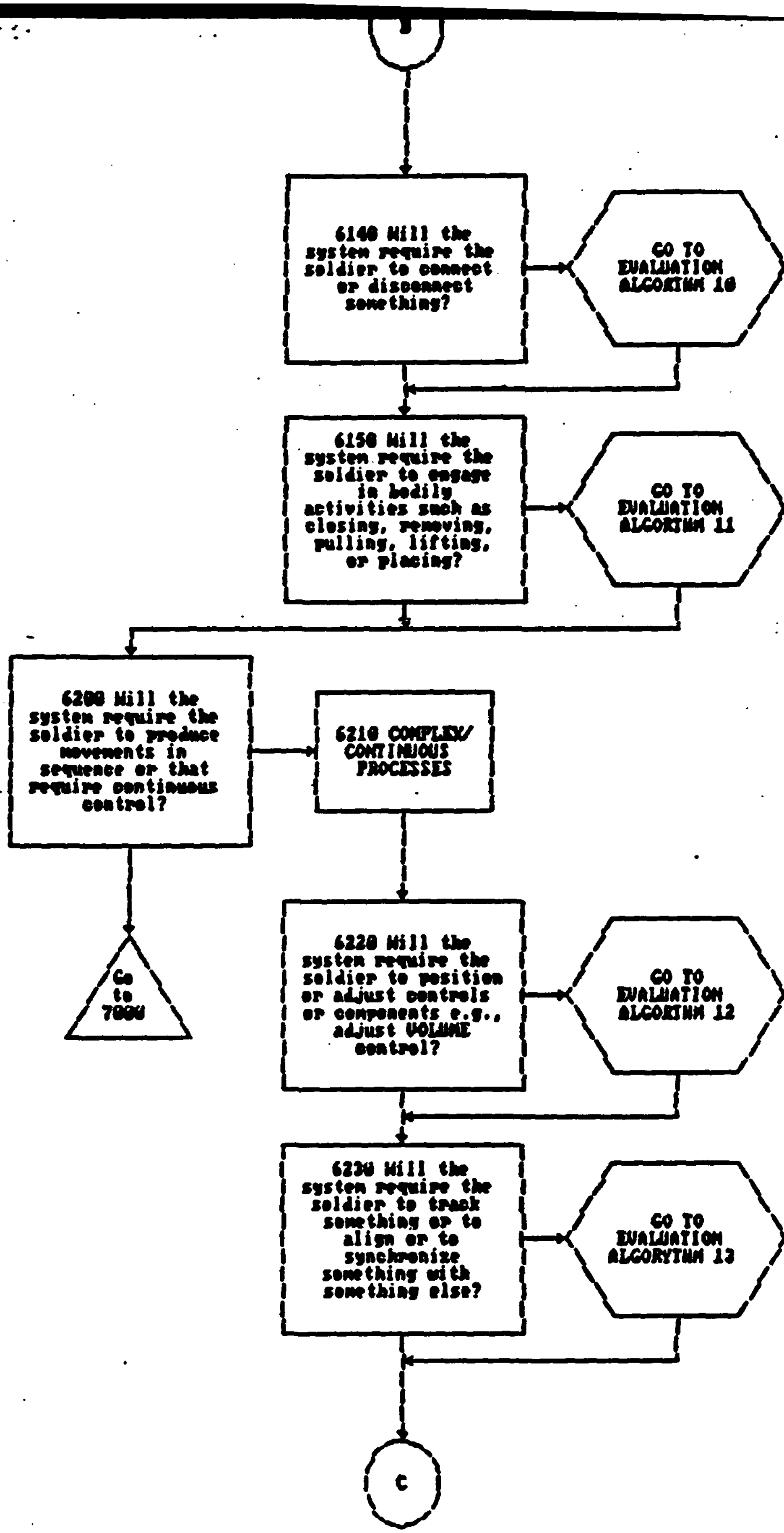


Figure 3.2.2
Evaluation System Flow Control and System/User Interface Screens


A
4200 Will the system require the soldier to analyze information, make estimates/ judgments, or apply existing rules or principles to arrive at logical conclusions?
GO TO EVALUATION ALGORTHM 6
5000 Will the system require the soldier to use communication processes?
5100 Will the system require the soldier to transmit messages/signals/ code, make requests, exchange ideas, provide instruction, or advise a course of action?
GO TO EVALUATION ALGORYTHM 7
6000 Will the system require the soldier to use motor (movement) processes?
6100 Will the system require the soldier to produce simple movements with a distinct beginning and end, e.g., flipping a switch, closing a cover?
6110 SIMPLE/DISCRETE PROCESSES
Go to 7000
6120 Will the system require the soldier to activate something e.g., turn PWR switch on, release slide to chamber a round, press trigger?
GO TO EVALUATION ALGORYTHM 8
6130 Will the system require the soldier to set or lock something into position, e.g., set band switch to 53-75, push safety lock to safe position, pull hood over head?
GO TO EVALUATION ALGORYTHM 9
B


6140 Will the system require the soldier to connect or disconnect something?
GO TO EVALUATION ALGORTHM 10
6150 Will the system require the soldier to engage in bodily activities such as closing, removing, pulling, lifting, or placing?
GO TO EVALUATION ALGORTHM 11
6200 Will the system require the soldier to produce movements in sequence or that require continuous control?
6210 COMPLEX/ CONTINUOUS PROCESSES
Go to 7000
6220 Will the system require the soldier to position or adjust controls or components e.g., adjust VOLUME control?
GO TO EVALUATION ALGORTHM 12
6230 Will the system require the soldier to track something or to align or to synchronize something with something else?
GO TO EVALUATION ALGORYTHM 13
C

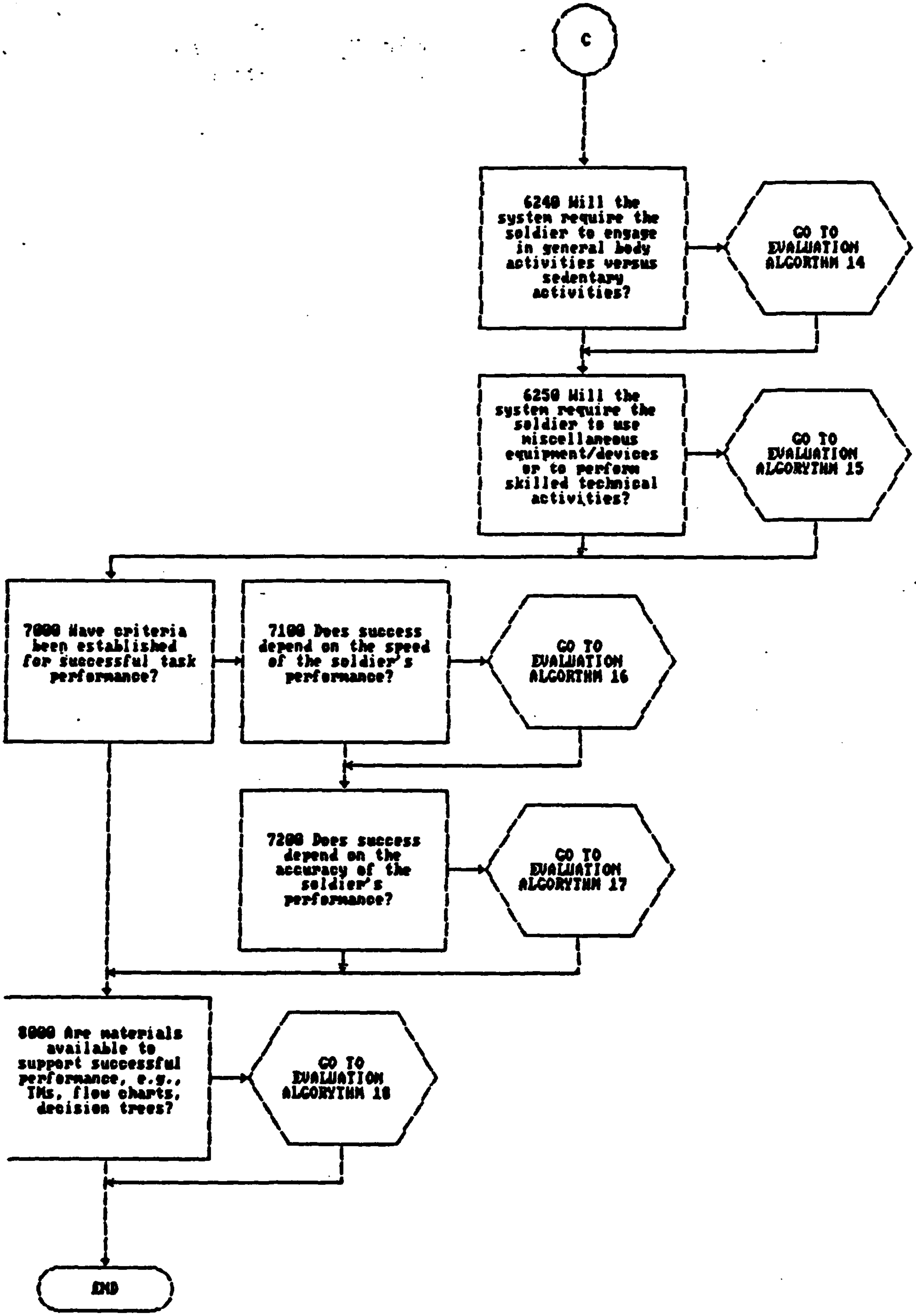

C
6240 Will the system require the soldier to engage in general body activities versus sedentary activities?
GO TO EVALUATION ALGORTHM 14
6250 Will the system require the soldier to use miscellaneous equipment/devices or to perform skilled technical activities?
GO TO EVALUATION ALGORYTHM 15
7000 Have criteria been established for successful task performance?
7100 Does success depend on the speed of the soldier's performance?
GO TO EVALUATION ALGORTHM 16
7200 Does success depend on the accuracy of the soldier's performance?
GO TO EVALUATION ALGORYTHM 17
8000 Are materials available to support successful performance, e.g., TMs, flow charts, decision trees?
GO TO EVALUATION ALGORYTHM 18
END

figure represents a user interface screen that asks the user for information. This information is used to identify which of the product's evaluation algorithms are relevant for the system under review.

The text of these user interface screens (the large boxes) should be reproduced exactly by the systems hardware and software. The text of the questions will fit on a single standard size screen. Users will indicate their yes or no responses to the questions through the keyboard and the system will verify that these response was within the proper range.

The smaller boxes towards the right of Figure 3.2.2 represent calls to the products evaluation algorithms. The functioning of the evaluation algorithms will be discussed in Section 3.3.2.

3.3 Evaluation Process

Once a human activity has been identified as being pertinent for the system undergoing review the product must determine the levels of the appropriate human abilities that will be required to perform that activity successfully. The product will accomplish this function through a rating scale to input the performance requirements and a set of linear algorithms to convert this information into ability requirements. The resulting data and the necessary background data will then be stored for further analysis.

3.3.1 Performance Rating Scale. The level of a human ability required of the personnel within a system will depend upon the accuracy requirements of the activities they must perform. Figure 3.3.1 shows the rating scale that will be used to input this information into Product Six. This rating scale is a product user interface screen and will be produced by the product's hardware and software exactly as shown in the figure. The same rating scale will be used be used by each of the product's evaluation algorithms.

The user will use the system effectiveness information provided by Product One as the basis for his or her performance rating. The user will make a rating by moving the indicator arrow with the cursor control keys to the desired point by then entering a return.

3.3.2 Evaluation Algorithms. After the user has made a rating that indicates the required level of human performance for a given activity, a linear algorithm will compute the levels of the relevant human abilities required to obtain that performance. These algorithms are presented in Figures 3.3.2 and 3.3.3. The algorithms are numbered to correspond to the calls made to evaluation algorithms in the evaluation system flow control diagrams (Figure 3.2.2). (Algorithms 16, 17 and 18 that were referred to in Figure 3.2.2 will be part of the product's task-job integration functions. These algorithms are therefore not displayed in these figures.)

The algorithms in Figure 3.3.2 will be used to determine the basic human abilities that will be required of the system. The output of this information (described in section 3.3) will be useful in comparing projections of ability demand versus supply (output from Product Three). Combinations of these abilities could also be used to estimate job entry requirements if the Army chooses to expand its enlistment criteria based upon the results of Project A.

As noted above, the algorithms within Figure 3.3.2 should prove useful in comparing the basic human ability requirements of a system to the projected supply of those abilities. The Army, however, does not now use such basic information for the selection or classification of soldiers. If Product Six is to be truly meaningful to Army users, it must address such requirements as part of the evaluation of a system. The algorithms presented in Figure 3.3.3 evaluate the system's human performance requirements in terms of the variables now used by the Army as enlistment criteria. The output from these algorithms (again described in section 3.4) can be used in much the same manner as those in Figure 3.3.2, but the analysis will likely have greater immediate impact, since they will be expressed in terms that the Army now uses operationally.

<u>3.3.3 Data Storage Requirements.</u> After the ability levels required of a given activity have been determined, the system will need to store the relevant information for further analysis. The data to be stored must include:

1. Background data as entered during the background information definition,
2. The name of the job and task under evaluation,

3. The block number (see evaluation system flow diagrams) of the activity that led to the ability requirements.
4. The required level of performance as entered by the user on the rating scale.
5. The level of requirement for each of the basic abilities and Army enlistment criteria as output from the evaluation algorithms in Figures 3.3.2 and 3.3.3.

This information will be maintained in a special file within the product's data base management system. It will be used in the summary analysis and evaluation output (described in section 3.4).

Figure 3.3.1

Activity Performance Rating Scale

```
--------------------------------------------------------------------
|                                                                  |
|          Rate the average accuracy required of the               |
|          soldiers performing this activity that is               |
|          needed to achieve mission performance goals             |
|                                                                  |
|                                      --   100%                    |
|                                     |                             |
|                                     |-    80%                     |
|      Use the up          ======>    |                             |
|      or down arrow                  |                             |
|      keys to move                   |-    60%                     |
|      the indicator,                 |                             |
|      and the return                 |                             |
|      key to enter a                 |-    40%                     |
|      response.                      |                             |
|                                     |                             |
|                                     --    20%                     |
|                                                                  |
--------------------------------------------------------------------
```

Activity Evaluation Screen To be Presented Before Each Evaluation Algorithm in order to Indicate the Required Level of Performance

Figure 3.3.2
Evaluation Algorithms for
Basic Human Ability Predictors of Performance

Algorithm Number	Basic Ability Predictor Equation
1	Accuracy% = .26+.0007(Spatial)+.006(Psychomotor)
2	Accuracy% = .21(-1)+.002(Num.)+.002(Tech.)+.007(Spatial)
3	Accuracy% = .19+.001(Num.)+.001(Speed)+.009(Spatial)
4	Accuracy% = .41+.0002(Num.)+.0005(Speed)+.0002(Spatial)
5	Accuracy% = .19+.001(Num.)+.001(Speed)+.0008(Spatial)
6	Accuracy% = .04+.003(Num.)+.0009(Spatial)
7	Accuracy% = .32+.002(Verbal)+.0008(Speed)
8	Accuracy% = .20+.006(Spatial)
9	Accuracy% = .65+.0014(Tech.)+.0004(Spatial)+.0002(Psycho.)
10	Accuracy% = .54+.001(Technical)
11	Accuracy% = .00+.002(Num.)+.002(Speed)+.001(Spatial)
12	Accuracy% = .32+.002(Verbal)+.0004(Spatial)
13	Accuracy% = .32+.002(Verbal)+.0004(Spatial)
14	Accuracy% = .69+.0013(Tech.)+.0003(Psychomotor)
15	Accuracy% = .69+.023(Num.)-.05(Tech.)+.031(Speed)+.001(Spa.)

Figure 3.3.3

Evaluation Algorithms for

Current Army Enlistment Criteria

Algorithm Number	ASVAB AA Composite Score	ASVAB Mental Category Score
	Accuracy% =	Accuracy% =
1	.00 + .0052(AA)	.56 + .0019(AFQT)
2	.12 + .0049(AA)	.49 + .0025(AFQT)
3	.45 + .0022(AA)	.59 + .0015(AFQT)
4	.54 + .0018(AA)	.68 + .0008(AFQT)
5	.48 + .0018(AA)	.59 + .0013(AFQT)
6	.14 + .0042(AA)	.44 + .0026(AFQT)
7	.17 + .0040(AA)	.45 + .0024(AFQT)
8	.20 + .0027(AA)	.41 + .0015(AFQT)
9[1]	.80 + .0003(AA)	.82 + .0002(AFQT)
10	.64 + .0015(AA)	.76 + .0007(AFQT)
11	.35 + .0025(AA)	.52 + .0017(AFQT)
12	.43 + .0029(AA)	.65 + .0017(AFQT)
13	.43 + .0029(AA)	.65 + .0017(AFQT)
14	.38 + .0029(AA)	.60 + .0017(AFQT)
15	.54 + .0014(AA)	.81 + .0013)AFQT)

1. This evaluation algorithm is based upon a regression line that was not found to be statistically significant under these analysis conditions.

3.4 Output Screens

When the process described in Figure 3.2.2 is complete, the user will be asked if he wishes to review the results of the process. Two levels of results will be available: tasks or jobs. The user will be able to select from a system prompt the level of analysis that he or she wishes to review.

3.4.1 Task Evaluation Output Screens. If the user wishes to review the analysis for a particular task, the system will ask for the appropriate system and task name or id. The product will then produce the display the relevant information for the task of concern.

Figure 3.4.1 shows the output screens for a task evaluation. The product's hardware and software will produce these interface screens in the precise format shown in the figure. The specific data (i.e., the percentiles) will be obtained through table lookups based upon the results of the evaluation algorithms (Figures 3.3.2 and 3.3.3). In addition to presenting the evaluation information on the computer screen, a system prompt will ask the user if a hard-copy printout is desired.

3.4.2 Job Evaluation Output Screens. If a user wishes to summarize the analysis at the job or MOS level, the product will query for the appropriate system and job name. The product will then exhibit the relevant ability information summarized for the job of interest.

Figure 3.4.2 presents the user interface screens for this job summary information. The specific data (i.e., ability distributions) will be obtained through system summary analysis of the results of the evaluation algorithms (Figures 3.3.2 and 3.3.3) maintained in the product's data base. The format of the screens will be as shown in the figure. As was the case with the task evaluation outputs, the system will also present the user with an option for hard-copy output.

3.4.3 Data Base Storage of Evaluation Results. Whenever a task or job evaluation is requested by a user, the results of that evaluation will be stored in a product data base file, as well as being sent to the screen or printer. If these results are requested again they can then be called from the data base rather than being recalculated. This data will also provide an audit trail of the evaluation process for any system reviews that are required.

Separate summary files will be maintained for task and job evaluations. Output results will be identified using the system and job-task names as key fields. All of the evaluation data displayed on the output screens (Figure 3.4.1 and Figure 3.4.2) will be included in the data base files.

Figure 3.4.1

Task Evaluation Output Screens

System Name ____________________

Task Name ____________________

Basic Human Ability Requirements

Verbal Ability Requirement	(Percentile)	________
Numerical Ability Requirement	(Percentile)	________
Technical Ability Requirement	(Percentile)	________
Processing Speed Requirement	(Percentile)	________
Spatial Ability Requirement	(Percentile)	________
Psychomotor Ability Requirment	(Percentile)	________

Sample

Task Evaluation Output

Screen Number 1

Basic Human Ability Information

System Name ____________________

Task Name ____________________

Army Enlistment Criteria Information

ASVAB AA Composite Score Best Predicting Performance

____

Confidence Interval (90%) Around AA Composite Score

____

Sample

Task Evaluation Output

Screen Number 2

Army Enlistment Criteria Information

Figure 3.4.2

Job Evaluation Output Screens

System Name ____________________

Task Name ____________________

<u>Basic Human Ability Requirements</u>

Verbal Ability Requirement	(Percentile)	________
Numerical Ability Requirement	(Percentile)	________
Technical Ability Requirement	(Percentile)	________
Processing Speed Requirement	(Percentile)	________
Spatial Ability Requirement	(Percentile)	________
Psychomotor Ability Requirement	(Percentile)	________

Sample

Task Evaluation Output

Screen Number 1

Basic Human Ability Information

System Name ____________________

Task Name ____________________

Army Enlistment Criteria Information

ASVAB AA Composite Score Best Predicting Performance

____

Confidence Interval (90%) Around AA Composite Score

____

Sample

Task Evaluation Output

Screen Number 2

Army Enlistment Criteria Information

System Name ______________________

Job Name ______________________

<u>Army Enlistment Criteria Information</u>

Recommended ASVAB AA Composite Cutoff Score

____

Recommended ASVAB Mental Category Distribution

```
            |
            |                  *            *
   % in     |          *       *            *
    Job     |          *       *            *
            |   *      *       *            *
            |   *      *       *            *          *
            ---------------------------------------------
                I      II     IIIA         IIIB        IV
```

Sample

Job Evaluation Output

Screen Number 1

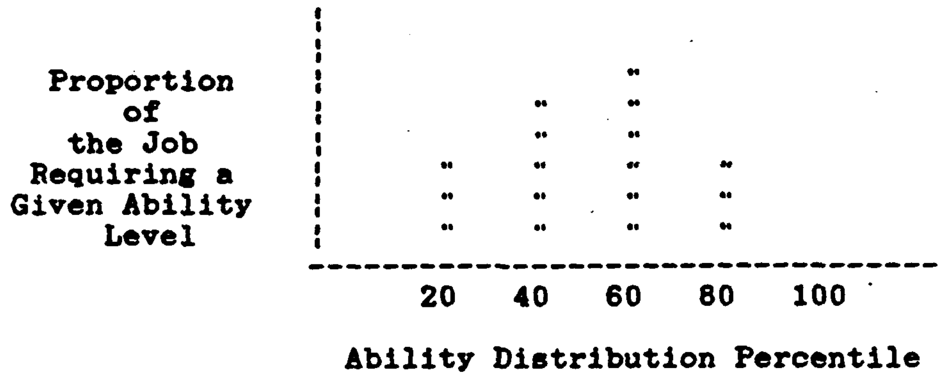
Army Enlistment Criteria Information

System Name ____________________

Job Name ____________________

Basic Human Ability Distributions

Verbal Ability Requirement



Sample

Job Evaluation Output

Screen Number 2

Basic Human Ability Information

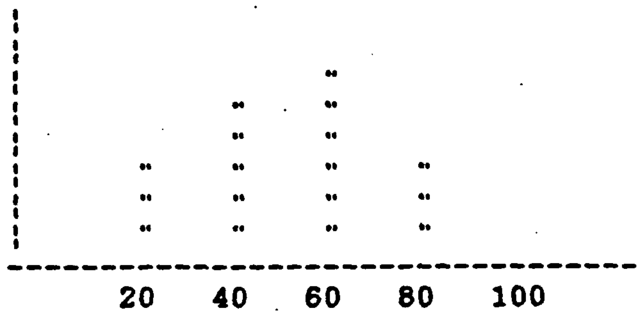
System Name ____________________

Job Name ____________________

<u>Basic Human Ability Distributions</u>

Numerical Ability Requirement

Proportion
of
the Job
Requiring a
Given Ability
Level



Ability Distribution Percentile

Sample

Job Evaluation Output

Screen Number 3

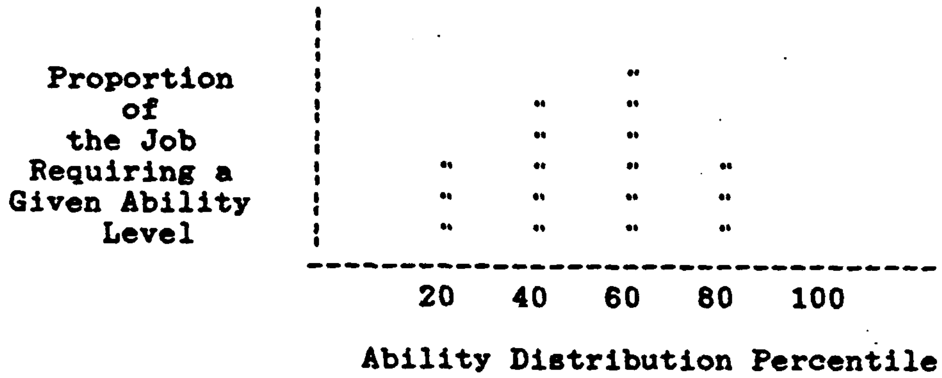
Basic Human Ability Information

System Name ____________________

Job Name ____________________

<u>Basic Human Ability Distributions</u>

Technical Ability Requirement



Sample

Job Evaluation Output

Screen Number 4

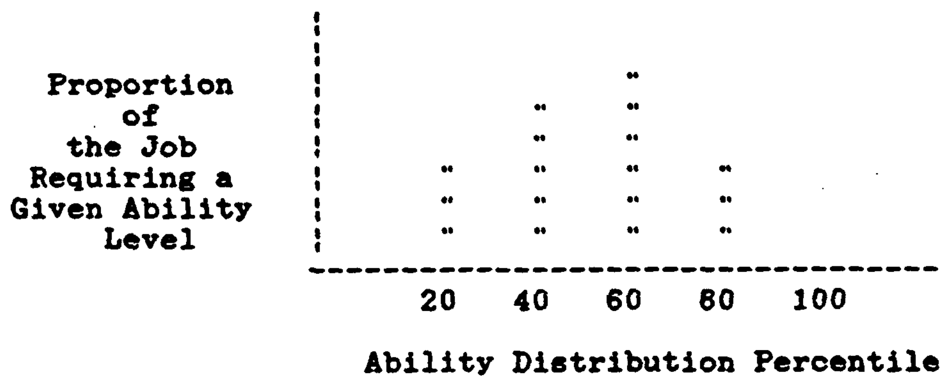
Basic Human Ability Information

System Name ______________________

Job Name ______________________

<u>Basic Human Ability Distributions</u>

Processing Speed Requirement



Sample

Job Evaluation Output

Screen Number 5

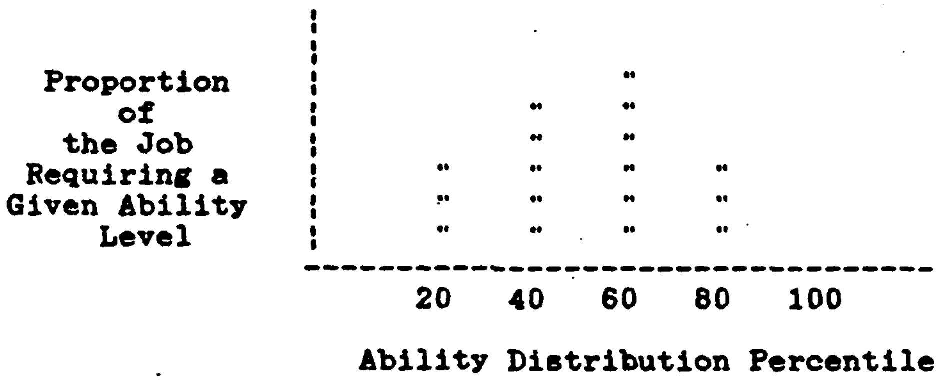
Basic Human Ability Information

System Name ____________________

Job Name ____________________

<u>Basic Human Ability Distributions</u>

Spatial Ability Requirement



Sample

Job Evaluation Output

Screen Number 6

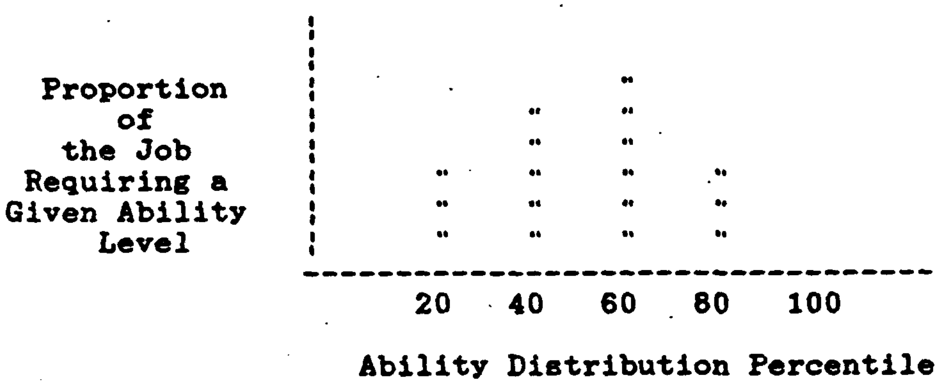
Basic Human Ability Information

System Name ______________________

Job Name ______________________

<u>Basic Human Ability Distributions</u>

Psychomotor Ability Requirement



Sample

Job Evaluation Output

Screen Number 7

Basic Human Ability Information

Section 4.0:
References

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